Interactive 3D visualisation of flood impact to critical infrastructure

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Summary

In the paper, we present an innovative application that allows stakeholders to interactively visualise the evolution of flooding and its impact to critical infrastructure using a standard web browser without any other software requirement. The system can demonstrate not only the maximum flood extent on a plain map, but also spatiotemporal varied information in 3D for any locations within the modelling domain that a user specifies. It can also be linked to online real-time flood modelling and risk assessment tools to provide risk-based early warning such that decision makers can prioritise emergency response actions to better protect critical infrastructure during extreme flood events.

Keywords

Urban drainage, international conference, conference paper, paper template, electronic files

Introduction

Flood modelling has been widely applied to analyse the consequences of flood hazards, which results are often displayed in a 2D map format, that only demonstrates a fixed snapshot of flood situation, normally maximum flood depth or velocity. The flood movement during an event are exported as animations, following a pre-defined viewing point or route, that audiences have no opportunity to inspect flood situation from a different angle. Professional software is required to enable users interactively examining the spatiotemporal evolution of flooding during an event, which limits the public to actively improve their understanding of the propagations of flood hazard and risk.

Methodology

To bridge the above-mentioned information gap, we are proposing a new approach that allow a user can interactively manipulate the system to visualise the impact of flooding in a 3D environment. We analyse the time series snapshots of flood modelling results to identify the flood impact to critical infrastructures (CIs), which are fed into a 3D visualisation model that users can easily operate in a standard web browser. This will provide users opportunities to explore and investigate more details regarding flood dynamic, consequently, risk communication will be enhanced because of improved understanding.

Risk Assessment

The time series rasters of flood hazards (e.g. flood depth, velocity) from modelling results are overlapped with the locations of CIs to flag up the assets to be compromised by the hazards. Due to the difficulty to collect detailed service area from the CI operators, spatial analysis algorithm was developed to determine the service area of a CI, which was used to associate customers (e.g. buildings for energy and water supply) within the area to the CI. Each frame of flood hazard raster was analysed to identify the CI assets that are inundated. Once the water depth exceeds a given threshold, which represents the flood will lead to the failure of the asset and disrupt its service, the associated customers will be flagged up to indicate the impact of the flooding.

Various types of CIs may have different service areas, and the interdependencies between CI services could lead to cascading effects that execrate the hazard impact. Therefore, if an affected customer provides another type of service, these secondary customers will also be flagged up and so forth.

3D Visualisation

We adopt Javascript and optimised WebGL technology based on the open source Three.js library [1] to develop the 3D visualisation system. The technology is so efficient that it can demonstrate complex terrain and flood data in real-time and only a web browser that support WebGL is required for viewing such information. Therefore, the 3D model allows a user to visualise the propagation of flood and its impacts along the time, while the user is moving the location of viewing point simultaneously. The system also provides additional visual effect functions that users can change the settings to emphasis particular information. Figure 1 shows several CIs (red for substation, orange for train station, and blue for hospital) in central Paignton, a part of Torbay in the UK, under dry condition. Figure 2 shows the same area under 1 in 200 year coastal flood scenario. Two substations inside the built areas near the coast line were inundated such that their red colour become darker and the buildings in their service area turned grey, no matter if the buildings were flooded or not.

Results and Discussion

Figure 2 shows an un-flooded building may suffer the flood impact due to the failure of the substation that is providing the electricity service to it. Through the approach, we clearly demonstrated the propagation of flood hazards, the impact to CIs, and the cascading effects for the services system. The interactive interface allows users to focus on specific areas and timing. The application can indicate when, where, and how will the flood disrupt the CI services through the 3D visualisation technology, which will increase the stakeholders' understanding of flooding and enhance their awareness.

Conclusions

We successfully developed the methodology to analyse the cascading effects of flooding and visualise the information via an innovate 3D model, which users can interactively operate, through a web browser, to have a comprehensive view of the service condition of CIs in a system at any time that have been analysed. The methodology is general and can be applied to analyse and visualise flood modelling results with standard raster or vector format. This approach will be a step stone to improve the risk communication between the flood modellers and the public.
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References

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